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ORIGINS OF SOCKEYE SALMON (Oncorhynchus nerka Walbaum)
IN THE TAKU-SNETTISHAM DRIFT GILLNET FISHERY OF 1983
BASED ON SCALE PATTERN ANALYSIS

By

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ABSTRACT

Mixed stocks of sockeye salmon *(Oncorhynchus nerka)* harvested in the 1983 District 111 gillnet fishery were allocated to the Taku River and Port Snettisham drainages using linear discriminant function analysis of scale patterns and age composition data. Accuracies of classification models for four age classes (age 1.2, 1.3, 2.2, and 2.3) ranged between 90.1% and 97.3%. Approximately 75% (23,892 fish) of the District 111 harvest of 31,627 sockeye salmon were bound for the Taku River. The total return of Port Snettisham stocks was estimated to be 37,641 sockeye salmon, of which 7,735 (20.6%) were taken in the District 111 fishery.

KEY WORDS: sockeye salmon, *(Oncorhynchus nerka)*, stock separation, linear discriminant function analysis.

INTRODUCTION

The District 111 gillnet fishery operates in Southeastern Alaska near Juneau in those waters of Stephens Passage north of a line from Point League to Pt. Hugh, and south and east of a line from a point at 58°12'20" N latitude, 134°10' W longitude, to Point Arden (Figure 1). The fishery typically is managed for sockeye salmon from its opening in mid-June through mid-August, after which time sockeye salmon catches are minimal and the fleet concentrates on coho and fall chum salmon. The average annual harvest of sockeye salmon during the period 1962 to 1982 was 54,886 fish, ranging from 17,735 to 123,081 fish. Sockeye salmon harvested in District 111 originate from drainages that empty into Taku Inlet and Port Snettisham (Figure 2). The vast majority of the sockeye salmon return to the Taku River is bound for spawning sites in Western British Columbia, Canada. Sockeye salmon returning through Port Snettisham to the Speel and Whiting River drainages are thought to spawn almost exclusively in Southeastern Alaska waters (Speel and Crescent Lakes).

A Canadian commercial gillnet fishery on the upper Taku River has annually harvested an average of 12,562 sockeye salmon since its inception in 1979. The fishery occurs upstream within 20 kilometers of the border between Alaska and British Columbia, and harvests fish bound for spawning sites in the Taku River and its tributaries.

Port Snettisham sockeye salmon stocks are extremely depressed relative to historical levels. An average of 55,225 sockeye salmon was commercially harvested in Port Snettisham between 1951 and 1954, in contrast to an average harvest level between 1975 and 1980 of only 4,649 fish. The Alaska Department of Fish and Game (ADF&G) identified the rebuilding of these runs as a management priority.

A critical and missing aspect of the sockeye salmon management program for the District 111 fishery has been the inability to identify the origins of fish harvested. This has to some degree prevented development of stock-specific management and probably contributed to the decline in abundance of the Port Snettisham stocks.

The feasibility of using scale pattern differences to separate principal Taku River and Port Snettisham stocks in the District 111 fishery was investigated for the 1981 and 1982 returns (McGregor et al. 1983). Nearest neighbor analysis of scale patterns of age 1.3 sockeye salmon showed that significant and likely persistent differences in freshwater and early marine growth patterns existed between principal component stocks which contribute to the fishery. The results suggested that while the ability to distinguish all individual stocks does not exist in some years using this technique, identification to either the Taku or Snettisham groupings should persist each year.

The purpose of this report is to provide estimates of the Taku and Port Snettisham contributions of sockeye salmon to the 1983 District 111 gillnet fishery. Linear discriminant function analysis of scale patterns for four

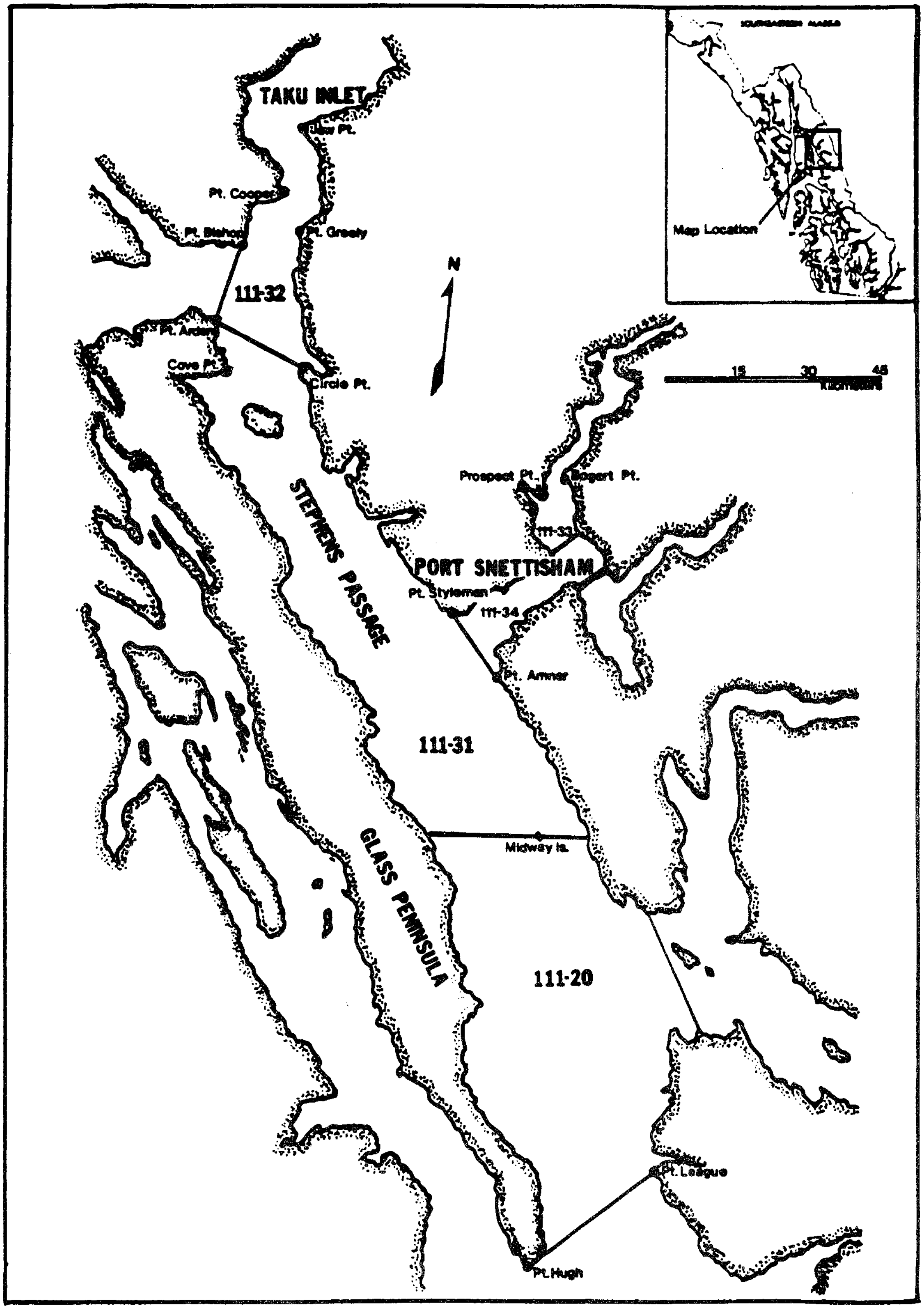

Figure 1. Map of the District 111 gillnet fishing area, with an inset of Southeastern Alaska.

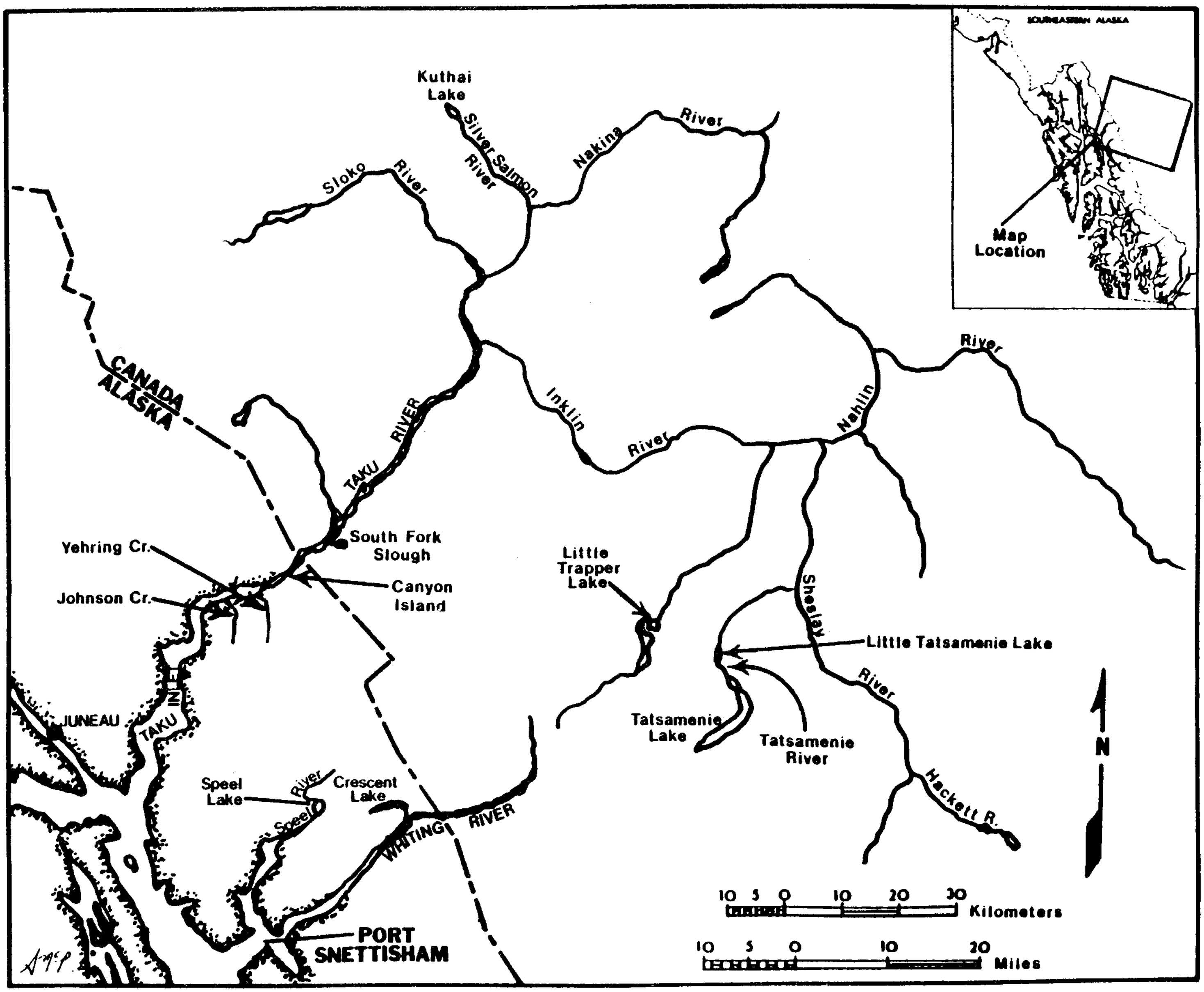

Figure 2. Map of the Taku, Speel, and Whiting River drainages, with an inset of Southeastern Alaska.

age classes of sockeye salmon was used to allocate the catch. By combining the catch allocation of the District 111 harvest with escapement estimates for the Port Snettisham drainages, the total return of Port Snettisham sockeye salmon could be estimated for 1983.

METHODS

Numbers of Fish

Catch statistics for the District 111 fishery were compiled by the Division of Commercial Fisheries, ADF&G, and originated from individual fish tickets tabulated as of 7 June 1984. Harvest statistics for the Canadian in-river fishery were provided by the Canadian Department of Fisheries and Oceans (Sandy Johnson, personal communication). Daily escapement counts to Crescent and Speel Lakes were made at weirs at these locations. A variety of methods were used to index escapements to specific spawning areas within the Taku River system. The Canadian Department of Fisheries and Oceans operated a weir at Little Trapper Lake. Aerial, boat, and foot surveys performed by the ADF&G provided indices of escapement for specific spawning stocks within the Taku River drainage. A mark-recapture study utilizing fishwheels and gill nets was initiated in 1983 to develop methodology needed to obtain accurate annual escapement estimates for the Taku River. Results of the mark-recapture study are not included in this report, but can be found in Mesiar and Bernard (in prep.).

Age Composition

Examination of scale samples provided age information for catches and escapements. Some otoliths were also collected from sockeye salmon carcasses on the spawning grounds. In cases where resorption of the marine growth made distinguishing marine age difficult, length frequency histograms and otoliths (when available) were used to assist in determining the correct marine age. Scales were collected from the left side of the fish approximately two rows above the lateral line and on the diagonal row downward from the posterior insertion of the dorsal fin (INPFC 1963). Scales were mounted on gummed cards and impressions were made in cellulose acetate (Clutter and Whitesel 1956). Ages were recorded in European[1] notation. Sex determination was made by examination of external morphological features or gonads. Detailed sex data is not presented in this report, but can be found in McGregor et al. (1984).

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[1] European formula: Numerals preceding the decimal refer to the number of freshwater annuli, numerals following the decimal are the number of marine annuli. Total age is the sum of these numbers plus one.

Catch:

The age compositions of both the District 111 and Canadian in-river gillnet harvests were estimated. Samples from both fisheries were collected each fishing period during the season. Samples from individual fishing periods were pooled when necessary into sample periods to allow the true proportion of each age class in the population to be estimated to within +/- 5%, nine times out of ten (Bernard 1982).

Escapement:

Scale samples were collected at Speel and Crescent Lake weirs throughout the season, and age compositions for the 1983 returns were estimated by weighting period age compositions by escapement during each sample period. Scale samples were taken in conjunction with the Taku River tagging program conducted at Canyon Island (Figure 2). Sockeye salmon were captured at Canyon Island with gill nets and fishwheels. It was not possible to estimate the age composition of the 1983 escapement of sockeye salmon to the Taku River drainage since the age composition of fish sampled at Canyon Island varied considerably by the gear type used to capture fish, and because both gear types were not fished continuously throughout the return. The age compositions of specific spawning stocks in the Taku River drainage were estimated from samples collected using a variety of methods including beach seining, carcass sampling, and spearing.

Stock Identification

Estimates of the contribution of Taku River and Port Snettisham sockeye salmon to the District 111 commercial catch were made using linear discriminant function analysis of scale patterns and age composition.

Scale Measurements:

Scale images were magnified to 100 power, projected onto a digitizing tablet using equipment similar to that described by Ryan and Christie (1976), and measurements were made and recorded by a microcomputer-controlled digitizing system. Scale measurements were taken along a standardized axis approximately 20° off the primary axis and perpendicular to the sculptured field. The distance between each circulus in each of four scale zones was measured (Figure 3). The zones were: (1) the scale focus to the last circulus of the first freshwater annulus, (2) the last circulus of the first freshwater annulus to the last circulus of the second freshwater annulus (ages 2.2 and 2.3 only), (3) the last circulus of the last freshwater annulus to the last circulus of freshwater growth (plus growth), and (4) the last circulus of freshwater growth to the last circulus of the first ocean annulus. Forty-four scale characters (Table 1) were calculated from the basic incremental distances and circuli counts.

Analytical Procedures:

Linear discriminant function (LDF) analysis (Fisher 1936) of scale measurements was used to allocate the 1983 District 111 sockeye salmon gillnet

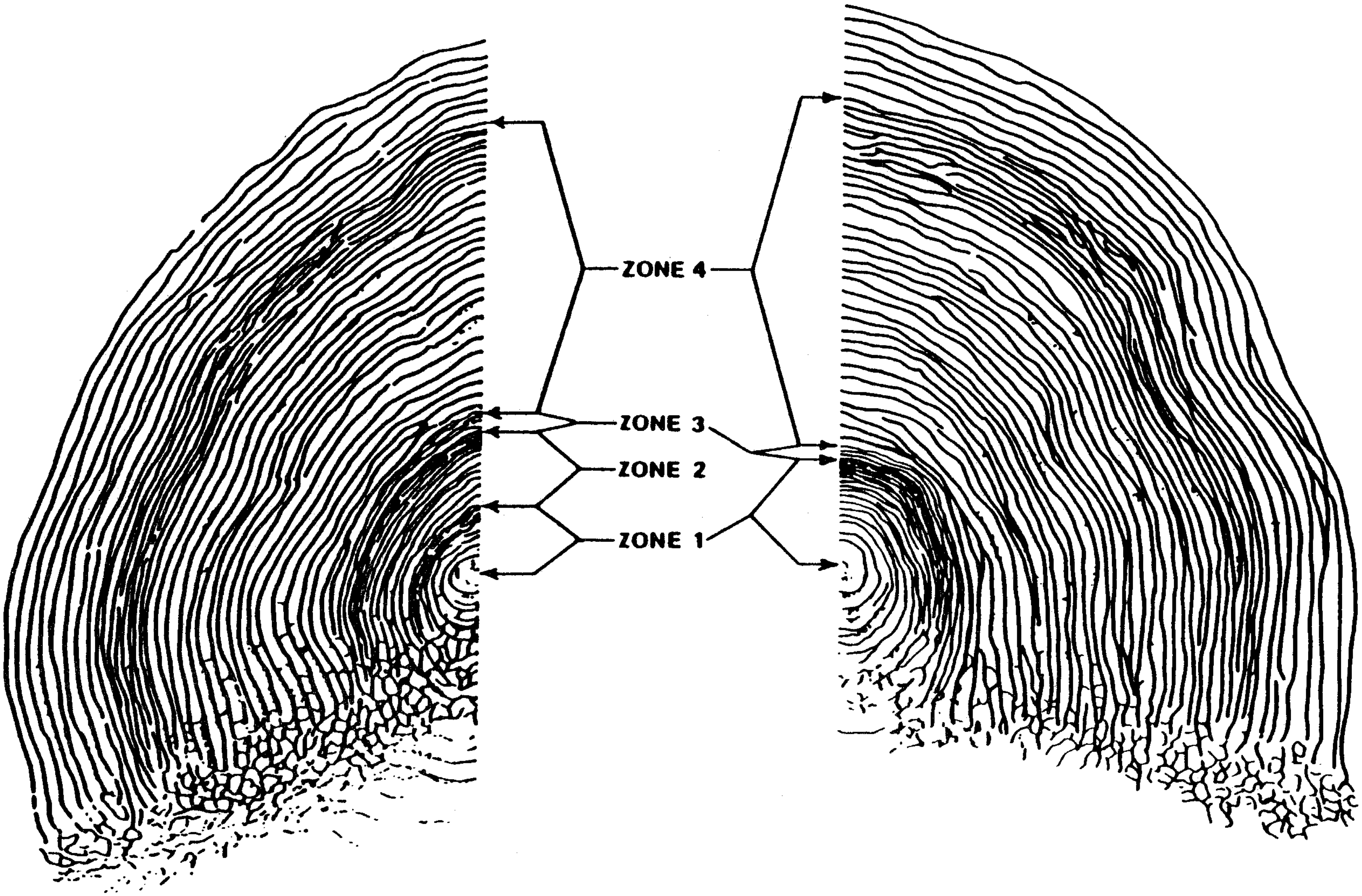

Figure 3. Typical scales for freshwater age 1. and 2. sockeye salmon showing the zones used to measure scale patterns.

Table 1. Variables computed from scale pattern measurements for inclusion in the linear discriminant function analysis.

Variable Name	Description
NC(i)[1]	Number of circuli in zone (i).
ID(i)	Measured size of zone (i).
TWO(i)	Distance from the beginning of zone (i) to the second circulus of zone (i).
FOUR (i)	Distance from the beginning of zone (i) to the fourth circulus of zone (i).
SIX (i)	Distance from the beginning of zone (i) to the sixth circulus of zone (i).
EIGHT (i)	Distance from the beginning of zone (i) to the eighth circulus of zone (i).
MIN (i)	The minimum distance between two contiguous circuli in zone (i).
MAX (i)	The maximum distance between two contiguous circuli in zone (i).
LMIN (i)	The distance from the beginning of zone (i) to the first circulus of variable MIN (i) in zone (i).
LMAX (i)	The distance from the beginning of zone (i) to the first circulus of variable MAX (i) in zone (i).
NCH (i)	The number of circuli in the first half of zone (i).

[1] Where i = 1,2,3,4.

harvest. Nearest neighbor analysis, a nonparametric technique that requires no underlying assumptions of population parameters, was used to discriminate between stocks in the feasibility study (McGregor et al. 1983) because many scale variables were not normally distributed (violating a basic assumption of LDF). Only normally distributed scale variables were used in the 1983 analysis so the more computationally complex and costly nearest neighbor analysis was not used. Univariate normality of variables does not ensure normality in the multivariate case, but the LDF has been shown to be robust to violations of this assumption (Krzanowski 1977). Age-specific models were developed for the 1.2, 1.3, 2.2, and 2.3 age classes. Although age 0.3 fish comprised a significant portion (6.4%) of the catch, inadequate numbers of scales from this age class were available from Port Snettisham systems to construct a model.

Since the primary emphasis of this study was to allocate catches to either the Taku River or Port Snettisham, and previous analyses demonstrated the inability of scale pattern analysis to separate Port Snettisham stocks from one another (McGregor et al. 1983), Snettisham stocks were pooled and two - group LDF models were constructed. Scales from each of Crescent and Speel Lakes, chosen in proportion to the relative contribution of an age class to the total Port Snettisham escapements of that age class, were used to create the Snettisham standards. Scales from fish captured with fishwheels and gill nets at Canyon Island were used to develop the Taku standards. Scales were selected randomly for measuring throughout the entire return and in approximate proportion to their abundance by age class through time in the Canyon Island catches. This resulted in more representative Taku River standards than used in the feasibility study, in which only two (Little Trapper and Kuthai Lakes) of the many contributing Taku River stocks were represented.

Measurements from 200 scales were desired for each standard for an age class. Standards were built with less than 200 scales for all age classes except age 1.3, however, because not enough scales from the appropriate age class were available from one or both of the stock groupings.

Stepwise linear discriminant function analysis (Dixon and Brown 1979) was used to develop the age-specific classification models. Variables were allowed to enter the models until there were no significant increases in classification accuracy due to the addition of the last variable. A nearly unbiased estimate of classification accuracy for each LDF was determined using a jackknife procedure (Lachenbruch 1967).

Scale pattern data from the District 111 commercial catch were classified and stock composition estimates were made for each age class. Stock composition estimates were then adjusted for misclassification errors using the procedures of Cook and Lord (1978). The variance and 90% confidence intervals for these estimates were then computed using the procedures of Pella and Robertson (1979).

Contribution rates were estimated for age 1.3 fish for each of the first eight fishing periods, with the remaining fishing periods pooled into one stratum for this age class. A criterion of approximately 100 scales per age class from fish of unknown stock composition in the commercial catch were used to denote strata. Because of the limited availability of scales from the remaining age classes in the catch, samples were pooled over sampling periods. Four contribution rates were estimated throughout the season for age 1.2 and 2.3 fish, and two for age 2.2 fish. Fish from the combined 'other' age classes, which represented only 7.0% of the catch, were allocated to the Taku and Snettisham groupings by multiplying the number of fish from this category in each fishing period by the percent allocation of the total catch of the other four age classes per period. An approximate 90% confidence interval for the season's total allocation was estimated (see Appendix C; Oliver et al. 1985).

RESULTS

Numbers of Fish

The harvest of 31,627 sockeye salmon in the District 111 gillnet fishery was the lowest since 1968. Fishing began in the third week of June and continued through 24 September, a total of 14 weeks (Table 2). Specific time and area regulatory measures are summarized in Table 2. Over 81% (25,763 fish) of the catch was taken in Taku Inlet (111-32). Slightly over 15% (4,827 fish) of the catch was taken in Stephens Passage (111-31). Catches in Port Snettisham (111-33 and 111-34) accounted for only 3% (1,037 fish) of the harvest.

A variety of fishing area closures and fishing time restrictions were employed in an effort to minimize overharvesting the apparent poor returns to the Taku River drainage. Taku Inlet was closed north of a line from Pt. Greely to Pt. Cooper from 3-30 July. Taku Inlet was completely closed during the week of 17-23 July. Port Snettisham was closed from 10-30 July to prevent a shift in fishing effort to the expected poor return of Snettisham stocks (Muir, personal communication). These restrictions to a large degree were responsible for the two peaks in the District 111 catches. An early peak in catches occurred during the week of 3-9 July, followed by a second peak during the week of 24-30 July. Catches of sockeye salmon declined to less than 1,000 fish per week from 14 August through the remainder of the fishing season.

The in-river Canadian fishery began one week earlier than the District 111 fishery (Table 3). Two days of fishing were allowed for each of the first four weeks. Fishing time was increased to four days per week for the remainder of the season, which ended the week of 9-15 October. There were two peaks in the in-river harvest; each occurred one week later than corresponding peaks in the District 111 catch. A total of 17,026 sockeye salmon were taken by the Canadian gillnetters.

The daily escapements of sockeye salmon to each of the weired systems are detailed in McGregor et al. (1984). Nearly 30,000 sockeye salmon were estimated to have escaped to Port Snettisham spawning systems. A total of 10,484 sockeye salmon was counted through the Speel Lake weir, and 19,422

Table 2. District 111 fishery openings, effort, and harvest by week and subdistrict, 1982.

Statistical Week	Dates	Hours	Subdistrict 31 Boats	31 Catch	32 Boats	32 Catch	33 Boats	33 Catch	34 Boats	34 Catch	Total Catch
26[1]	6/19-25	72			25	2,360			1	9	2,369
27[1]	6/26-7/2	72	1	150	58	3,337					3,487
28[2]	7/3-9	48	11	436	63	5,222	1	32	2	84	5,774
29[2,3]	7/10-16	24			47	2,111	- closed -		- closed -		2,111
30[3,4]	7/17-23	48	20	889	- closed -		- closed -		- closed -		889
31[2,4]	7/24-30	96	14	1,945	29	4,558	- closed -		- closed -		6,503
32[5]	7/31-8/6	72	16	661	44	4,454			5	685	5,800
33[5]	8/7-13	72	12	402	27	1,753			4	141	2,296
34[5]	8/14-20	72	5	111	22	661			4	86	858
35[5]	8/21-27	72	3	105	27	529					634
36[5]	8/28-9/3	48	2	109	32	535					644
37[5]	9/4-10	48	8	19	35	190					209
38[5]	9/11-17	24			15	12					12
39[5]	9/18-24	24			20	41					41
Total				4,827		25,763		32		1,005	31,627

[1] Taku Inlet closed north of the latitude of Jaw Point.

[2] Taku Inlet closed north of a line from Point Cooper to Point Greely.

[3] Port Snettisham closed from Point Styleman to Point Amner.

[4] Taku Inlet closed. Stephens Passage (111-31) open south of a line from Cove Point to Circle Point.

[5] Speel Arm closed north of a line from Prospect Point to Bogert Point.

Table 3. Canadian commercial gillnet harvest of sockeye salmon from the Taku River, 1983.

Statistical Week	Dates	Days Fished	Boats	Catch
25	6/12-18	2	3	208
26	6/19-25	2	4	305
27	6/26-7/2	2	7	811
28	7/3-9	2	7	645
29	7/10-16	4	7	2,390
30	7/17-23	4	5	1,929
31	7/24-30	4	11	3,130
32	7/31-8/6	4	11	4,112
33	8/7-13	4	8	1,373
34	8/14-20	4	7	473
35	8/21-27	4	6	1,026
36	8/28-9/3	4	6	410
37	9/4-10	4	6	127
38	9/11-17	4	7	83
39	9/18-24	4	6	33
40	9/25-10/1	4	4	1
41	10/2-8	4	2	0
42	10/9-15	4	1	0
Total				17,026

were estimated to have returned to Crescent Lake[1]. The run timing of returns to these two lakes was affected severely by water level and temperature. Large freshets, which raised water levels and lowered water temperatures in the outlet streams of these lakes, were followed by large peaks in fish passage past the weirs. Between 7 and 15 August approximately 69% and 64% of the returns passed through Speel and Crescent Lake weirs, respectively. A total of 7,502 sockeye salmon was estimated to have escaped through the Little Trapper Lake weir, located in the Taku River drainage[2]. Over 85% of the estimated return to Little Trapper Lake passed the weir during the week of 4-10 August. Tagging results indicated an average migration time for sockeye salmon from the Canyon Island tagging site to Little Trapper Lake of approximately 30 days, although time required to travel this distance (170 km) decreased through the season (Mesiar and Bernard, in prep.).

Indices of escapement to other spawning sites in the Taku River drainage are presented in Table 4. These indices do not constitute estimates of escapement because the proportion of the escapement observed at each site was unknown and varied between locations. The survey counts are reported here because they are of potential use in qualitative interannual comparisons of individual spawning stock escapements.

Age Composition

Age composition data presented in this report are summarized in more detail by McGregor et al. (1984).

Catch:

Weekly age composition estimates for the District 111 harvest are summarized in Table 5. Five-year-old fish were most common in the catch throughout the season. Age 1.3 fish were the primary age class represented in the catch (68.8%), followed by age 2.3 (10.9%), age 1.2 (7.6%), age 0.3 (6.4%), and age 2.2 (5.7%). Other minor age classes comprised the remainder of the catch. The proportion of age 1.3 fish in the catch decreased throughout the season. Conversely the incidence of 0.+ and 2.+ freshwater fish in the catch increased during the season.

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[1] The Crescent Lake weir washed out on 24 August after 14,442 fish had passed through the weir. An estimated 5,000 sockeye salmon escaped into the system after the weir washed out.

[2] Small fish passing through the weir were not counted until 7 August, after which time the weir was covered with stucco wire to eliminate all the holes. Escapements were estimated for the period 4-6 August based on visual estimates of escaping fish and subsequent intensive carcass counts. Counts after 6 August are not estimates.

Table 4. Indices of escapement for specific spawning locations in the Taku River drainage. Abbreviations for types of surveys are as follows: (A) aerial, (B) boat, (H) helicopter, and (W) weir.

Stream Number	Stream Name	Count	Method	Date
111-32-066	Yehring Creek	70	A	8/29
111-32-068	Johnson Creek	30	A	8/29
111-32-201	South Fork Slough	950	B	8/24
111-32-220	Nakina River	400	A	9/26
111-32-235	Kuthai Lake	580	A	9/29
111-32-245	Little Trapper Lake	7,502	W	7/9-9/17
111-32-254/5/6	Tatsamenie Lake system	1,720	A	8/29
111-32-254	Little Tatsamenie Lake	994	W	8/28-9/3
111-32-255	Tatsamenie River	700	H	8/19
111-32-270	Nahlin River	174	H	7/29

Table 5. Percent age composition of the District 111 gillnet catch of sockeye salmon by sample period, 1983.

			BROOD YEAR AND AGE CLASS										
			1980	1979			1978			1977		1976	
Dates	Statistical Week	Sample Size	0.2	0.3	1.2	2.1	0.4	1.3	2.2	1.4	2.3	2.4	3.3
6/19-25	26	472		1.7	2.3			93.0	0.2		2.8		
6/26-7/2	27	587	0.5	2.6	9.5			72.4	1.0	0.5	13.5		
7/3-9	28	522		4.0	8.2			67.8	1.2	0.8	18.0		
7/10-16	29	540	0.9	5.7	11.3		0.2	63.9	2.4	0.6	14.8	0.2	
7/17-23	30	491	0.2	3.3	10.4			69.0	3.7	0.2	13.2		
7/24-30	31	531		9.8	6.4			69.9	6.6		7.3		
7/31-8/6	32	767	0.4	7.6	7.8		0.1	64.7	10.2	0.4	8.7		0.1
8/7-13	33	675		8.9	7.3		0.1	62.2	12.7	0.1	8.4		0.1
8/14-9/24	34-39	583	0.2	9.3	7.7	0.2	0.2	59.0	12.7	0.2	10.6		
Total		5,168	0.2	6.4	7.6	0.0+	0.1	68.8	5.7	0.3	10.9	0.0+	0.0+

Age composition estimates for the Canadian in-river harvest are summarized in Table 6. Sufficient samples were taken to divide the harvest into three sample periods for the purpose of estimating the age composition. Trends in the age composition of the catch were similar to those observed in District 111. Age 1.3 fish predominated in the catch (64.9%), followed by age 1.2 (11.9%), age 0.3 (10.3%), age 2.2 (6.3%), and age 2.3 (6.0%). As seen in the District 111 harvest, the proportion of age 1.3 fish in the catch decreased through the season. Age 0.3 fish increased from 2.1% of the catch in the first sample period to 15.0% in the final sample period. A similar increase was noted during the season for age 2.2 fish, which represented only 0.6% of the catch in the initial period but increased to 12.7% of the harvest in the final period.

Approximately equal proportions of males and females were taken in both the District 111 and Canadian in-river harvests (McGregor et al. 1984).

Escapement:

Significant differences in age composition were apparent both within and between escapements to the Taku River and Port Snettisham drainages (Table 7). For Port Snettisham systems, four-year-old sockeye salmon were predominate (62.3%) in the escapement to Crescent Lake, while five-year-old fish were most common (70.3%) in the Speel Lake escapement. Four-year-old fish were predominate in the early returns to Speel Lake, but the later and larger portion of the escapement was comprised primarily of five-year-old fish. Four-year-old fish were most common throughout the Crescent Lake return. The age composition of the escapement of sockeye salmon to Port Snettisham was derived by combining Speel and Crescent Lake age compositions according to the relative abundance of the two escapements. Age 1.2 sockeye salmon predominated (49.0%) in the escapement to Port Snettisham, followed by age 1.3 (37.8%), age 2.3 (6.2%), and small proportions of six other age classes. Males represented 61.5% of the escapement to Port Snettisham primarily due to the large proportion of age 1.2 males in the Crescent Lake escapement (McGregor et al. 1984).

It was not possible to estimate the age composition of sockeye salmon escapement to the Taku River drainage. The age composition of sockeye salmon at Canyon Island varied considerably by the gear type used to capture the fish. Smaller and younger fish were taken by fishwheels than by gill nets, although five-year-old fish were predominate in both. Specific spawning areas in the Taku River drainage exhibited an extreme diversity in age composition. Four-year-old fish represented the majority of the escapements to Little Trapper Lake (50.9%) and South Fork Slough (48.6%), while five-year-old fish were the most common age in escapements to Kuthai Lake (97.3%) and the Tatsamenie Lake system (55.7%). Zero freshwater age sockeye salmon, which did not spend a winter in freshwater after emergence, were common in South Fork Slough (32.7%). Age 0.+ sockeye salmon were common in the escapement to the Tatsamenie River (20.6%), a surprising result since this site is located over 190 km upstream from Canyon Island. Age 0.+ fish were not found, however, in a small sample of seventeen ageable scales taken from Tatsamenie Lake, out of which the Tatsemenie River flows. Sample sizes of escapements to the Nakina and Silver Salmon Rivers were too small for meaningful age compositions to

Table 6. Percent age composition of the Canadian commercial gillnet catch of sockeye salmon on the Taku River by sample period, 1983.

			1980	1979		1978		1977		1976
Dates	Statistical Week	Sample Size	0.2	0.3	1.2	1.3	2.2	1.4	2.3	3.3
6/12-7/16	25-29	526	0.4	2.1	8.4	83.0	0.6		5.3	0.2
7/17-8/6	30-32	612	0.5	12.4	13.7	59.3	6.5	0.2	7.4	
8/7-10/15	33-42	488	0.4	15.0	11.5	57.0	12.7		3.5	
Total		1,626	0.5	10.3	11.9	64.9	6.3	0.1	6.0	0.0+

Table 7. Percent age composition of escapement collections from the Port Snettisham and Taku River drainages, 1983.

Drainage	System	Sample Period	Sample Size	BROOD YEAR AND AGE CLASS										
				1980		1979			1978		1977			1976
				0.2	1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	3.3
Snettisham														
	Crescent Lake	1	607	1.6			57.8		28.2	2.8	0.7	8.9		
		2	580	1.9	2.4	0.3	60.4	0.3	22.8	3.1	0.5	8.3		
		3	497	2.8	2.4	0.4	62.6		19.7	3.6		8.5		
		Total	1,684	2.7	2.3	0.4	62.3	0.0+	20.2	3.6	0.0+	8.5		
	Speel Lake	1	395	0.8	2.3	0.2	48.1	0.2	44.6	1.8	0.2	1.8		
		2	398	0.3	1.0	0.3	16.6		78.5	1.0		2.3		
		Total	793	0.4	1.3	0.3	24.3	0.0+	70.3	1.2	0.0+	2.2		
	Total Drainage		2,477	1.9	2.0	0.3	49.0	0.0+	37.8	2.7	0.1	6.2		
Taku														
	Taku (Canyon Isl.) gill net	1	677	0.1		1.6	11.8		77.3	0.9		8.3		
		2	620			9.4	12.7		55.4	15.3	0.3	6.9		
		Total	1,297	0.1		5.3	12.3		66.7	7.8	0.2	7.6		
	(Canyon Isl.) fishwheel		277	1.8		7.2	36.5		42.2	6.1		5.8		0.4
	Little Trapper Lake		639		0.9		50.9		29.0	0.9		18.3		
	South Fork Slough		245	4.9	1.2	27.8	20.8		44.1	0.4		0.8		
	Kuthai Lake		486				1.7		96.5	0.8		1.0		
	Silver Salmon River		37				8.1		86.5	5.4				
	Tatsamenie Lake		17						88.2	5.9		5.9		
	River		238	0.8	1.7	19.8	24.4		50.8	2.1		0.4		
	Total		255	0.8	1.6	18.4	22.7		53.3	2.4		0.8		
	Nakina River		11			18.2	36.4		45.4					

be estimated, but the presence of 0.+ sockeye salmon in the Nakina River is notable. The sex composition of the Taku River escapements varied considerably by stock (McGregor et al. 1984). Males predominated in most spawning areas, especially in those that received high proportions of four-year-old returns. An estimated 70.6% and 57.1% of the escapements to Little Trapper Lakes and South Fork Slough, respectively, were males. The sex ratios of fish at Canyon Island varied by gear type used to capture the fish. The fishwheels caught younger and smaller fish that were predominantly males (62.8%), while the gill nets caught larger, older, and mainly female (56.1%) sockeye salmon.

Stock Identification

Linear discriminant function analysis of scale patterns was used to identify sockeye salmon from the Taku River and Port Snettisham drainages in the District 111 gillnet harvest.

Scale Measurements:

Summary statistics for the basic measurements of scale growth for the 1.2, 1.3, 2.2, and 2.3 age classes are presented in Table 8. Scale growth trends were similar for all four age classes. Taku River fish typically exhibited much greater freshwater growth and less growth in their first marine year than did Port Snettisham sockeye salmon. The variability in scale patterns of the Taku River fish was greater than in those from Snettisham stocks, as evidenced by the larger standard errors of the scale variables for the Taku River fish. This trend in scale patterns is not surprising since Taku River spawning sites and rearing areas are much more diverse and numerous than those in the Port Snettisham drainages.

Classification Accuracies:

Classification accuracies of the four age class specific models were very high (Table 9). Mean classification accuracies for the age 1.2 and 1.3 models were 90.1% and 90.5%, respectively. Even higher accuracies were obtained with the age 2.2 and 2.3 models, as would be expected because of the additional scale growth information available from the second year of freshwater growth to separate the groups. These high accuracies are indicative of the fact that differences in scale growth patterns between the Taku River and Port Snettisham sockeye salmon stock assemblages are much greater than differences within each group.

Age Class Specific Stock Composition Estimates:

Age class specific stock composition estimates were generated for time period strata that were as fine as possible (Table 10). Stock composition estimates generally revealed much higher contribution rates of Taku River fish than of Port Snettisham fish. The age-specific stock composition estimates were expanded to the catch for each strata, and the catches were allocated.

Table 8. Group means ($\bar{x}$) and standard errors of basic scale variables by age class (scale width measurements in 0.01's of inches at 100 X).

Age	Scale Variable[1]	Taku $\bar{x}$	Taku s.e.	Snettisham $\bar{x}$	Snettisham s.e.
1.2	ID1	123.2	2.5	75.8	1.3
	NC1	11.1	0.2	6.8	0.1
	ID3	21.2	1.0	23.6	0.9
	NC3	2.3	0.2	2.5	0.1
	ID4	389.2	3.4	413.5	3.2
	NC4	28.6	0.2	29.1	0.2
1.3	ID1	130.2	1.9	85.4	0.9
	NC1	11.7	0.2	7.8	0.1
	ID3	14.4	0.8	18.6	0.8
	NC3	1.6	0.1	2.0	0.1
	ID4	382.4	3.6	432.5	3.0
	NC4	26.2	0.2	27.9	0.2
2.2	ID1	101.5	2.1	66.1	1.9
	NC1	8.2	0.2	5.9	0.2
	ID2	129.7	2.5	63.1	3.1
	NC2	13.0	0.2	7.9	0.3
	ID3	16.1	1.2	19.6	1.4
	NC3	1.5	0.1	2.0	0.1
	ID4	353.7	6.1	410.5	6.6
	NC4	25.4	0.4	28.1	0.5
2.3	ID1	84.1	1.5	56.1	1.8
	NC1	7.6	0.1	5.1	0.2
	ID2	111.0	2.4	57.6	1.4
	NC2	11.7	0.2	7.2	0.2
	ID3	14.3	0.9	16.2	1.0
	NC3	1.4	0.1	1.7	0.1
	ID4	353.9	4.3	400.9	4.1
	NC4	24.0	0.3	27.3	0.3

[1] Descriptions of these variables are listed in Table 1.

Table 9. Classification matrices for the linear discriminant models used to classify age 1.2, 1.3, 2.2, and 2.3 sockeye salmon.

Age 1.2

Variables used (NC1,FOUR1,TWO1,ID4,NC4)

Actual Group of Origin	Sample Size	Classified Group of Origin	
		Taku	Snettisham
Taku	172	89.0	11.0
Snettisham	172	8.7	91.3

Mean Percentage Correctly Classified= 90.1%

Age 1.3

Variables used (ID1,ID4)

Actual Group of Origin	Sample Size	Classified Group of Origin	
		Taku	Snettisham
Taku	200	83.5	16.5
Snettisham	200	2.5	97.5

Mean Percentage Correctly Classified = 90.5%

Age 2.2

Variables used (ID2,ID1,ID4,NC4,MAX2)

Actual Group of Origin	Sample Size	Classified Group of Origin	
		Taku	Snettisham
Taku	55	100.0	0.0
Snettisham	55	5.5	94.5

Mean Percentage Correctly Classified = 97.3%

Age 2.3

Variables used (ID2,ID4,NC1,ID1)

Actual Group of Origin	Sample Size	Classified Group of Origin	
		Taku	Snettisham
Taku	98	93.9	6.1
Snettisham	98	4.1	95.9

Mean Percentage Correctly Classified = 94.9%

Table 10. Age class specific stock composition estimates and 90% confidence intervals calculated from scale pattern analysis of age 1.2, 1.3, 2.2, and 2.3 sockeye salmon in the District 111 commercial gill-net fishery by period, 1983.

Age Class	Dates	Sample Size	Statistical Week	Taku	Snettisham
1.2	6/19-7/9	86	26-28	.920±.095	.080±.095
	7/10-23	90	29-30	.431±.112	.569±.112
	7/24-8/6	75	31-32	.655±.121	.345±.121
	8/7-9/24	83	33-39	.807±.107	.193±.107
1.3	6/19-25	100	26	1.00 ±.000	.000±.000
	6/26-7/2	100	27	.820±.104	.180±.104
	7/3-9	100	28	.783±.105	.217±.105
	7/10-16	100	29	.685±.107	.315±.107
	7/17-23	100	30	.487±.104	.513±.104
	7/24-30	100	31	.857±.102	.143±.102
	7/31-8/6	100	32	.438±.102	.562±.102
	8/7-13	100	33	.635±.107	.365±.107
	8/14-9/24	117	34-39	.686±.100	.314±.100
2.2	6/19-8/6	99	26-32	.808±.068	.192±.068
	8/7-9/24	100	33-39	.979±.024	.021±.024
2.3	6/19-7/9	100	26-28	.910±.080	.090±.080
	7/10-23	89	29-30	.722±.099	.278±.099
	7/24-8/6	94	31-32	.814±.091	.186±.091
	8/7-9/24	96	33-39	.867±.086	.133±.086

Catch Apportionment

Approximately three-quarters (75.5%) of the 1983 harvest of sockeye salmon in District 111 was allocated to the Taku River (Table 11). The weekly catches for each run are shown in Figure 4. The abundance of Port Snettisham stocks in the catch was low until mid-July, after which time they became a more important segment of the catch. Almost 34% of the 10-16 July catch were Snettisham fish. Taku Inlet was closed the next week, 17-23 July, and Snettisham stocks represented a much higher proportion (47.3%) of the catch than in the previous week, although the total catch was extremely small (only 889 fish). Taku Inlet was reopened the following week and fishing effort shifted north to the Inlet. The largest weekly catch of the season was made during week 31 and the catch was comprised primarily of Taku River fish (83.6%). Portions of Port Snettisham were reopened the week of 31 July - 6 August, and a much higher proportion of the catch (46.6%) was allocated to Snettisham. Thirty-five percent of the Snettisham bound fish caught in 1983 in District 111 were taken during this week (statistical week 32). Small catches for the remainder of the season were apportioned roughly three-quarters to the Taku River and one-quarter to Snettisham stocks.

Run Reconstruction

Total return estimates for 1983 were generated for Port Snettisham sockeye salmon stocks (Table 12). The total estimated return of Port Snettisham stocks was 37,641 fish, of which an estimated 7,735 fish (20.6%) were harvested in the District 111 gillnet fishery. Exploitation rates of Port Snettisham stocks varied tremendously by age class, ranging from 33.8% for the age 1.3 age class to only 4.1% for the age 1.2 age class. Age 2.2 and 2.3 fish were exploited at rates of 23.0% and 21.3%.

DISCUSSION

Linear discriminant function analysis of scale patterns, in combination with age composition data, was used to allocate the District 111 harvest of sockeye salmon into Taku River and Port Snettisham stock groupings. Accuracies of the four age-specific classification models were all over 90%. These high accuracies were primarily responsible for the narrow confidence intervals of the catch allocation.

The District 111 fishery primarily harvested sockeye salmon destined for the Taku River drainage in 1983. Snettisham stocks were migrating through the District 111 fishery from early July throughout the remainder of the season. Peak escapement counts at Crescent and Speel Lakes in early to mid-August, together with reduced representation of Snettisham stocks in catches after the first week of August, indicate that the majority of Snettisham fish returned through District 111 between the first of July and the first week of August.

An undetermined number of fish bound for both the Taku River and Port Snettisham systems were intercepted in purse seine fisheries in Districts

Table 11. Estimated contribution of sockeye salmon originating from the Taku River and Port Snettisham drainages to the District 111 gillnet fishery, 1983.

Dates	Statistical Week	Group	Catch By Age Class					Total	
			1.2	1.3	2.2	2.3	Other	Numbers	Percent
6/19-25	26	Taku	51	2204	4	59	40	2358	99.6
		Snettisham	4	0	1	6	0	11	0.4
		Total	55	2204	5	65	40	2369	
6/26-7/2	27	Taku	306	2071	29	427	104	2937	84.2
		Snettisham	27	454	7	42	20	550	15.8
		Total	333	2525	36	469	124	3487	
7/3-9	28	Taku	438	3066	53	946	226	4729	81.9
		Snettisham	38	850	13	94	50	1045	18.1
		Total	476	3916	66	1040	276	5774	
7/10-16	29	Taku	103	924	41	226	106	1400	66.3
		Snettisham	135	425	10	87	54	711	33.7
		Total	238	1349	51	313	160	2111	
7/17-23	30	Taku	40	299	27	85	17	468	52.7
		Snettisham	52	314	6	33	16	421	47.3
		Total	92	613	33	118	33	889	
7/24-30	31	Taku	272	3894	346	389	533	5434	83.6
		Snettisham	144	650	82	89	104	1069	16.4
		Total	416	4544	428	478	637	6503	
7/31-8/6	32	Taku	297	1643	476	412	267	3095	53.4
		Snettisham	157	2108	113	94	233	2705	46.6
		Total	454	3751	589	506	500	5800	
8/7-8/13	33	Taku	135	907	287	168	153	1650	71.9
		Snettisham	32	522	6	26	60	646	28.1
		Total	167	1429	293	194	213	2296	
8/14-9/24	34-39	Taku	149	971	299	221	181	1821	75.9
		Snettisham	36	444	6	34	57	577	24.1
		Total	185	1415	305	255	238	2398	
Total		Taku	1791	15979	1562	2933	1627	23892 ±886[1]	75.5
		Snettisham	625	5767	244	505	594	7735 ±886	24.5
		Total	2416	21746	1806	3438	2221	31627	

[1] 90% confidence interval.

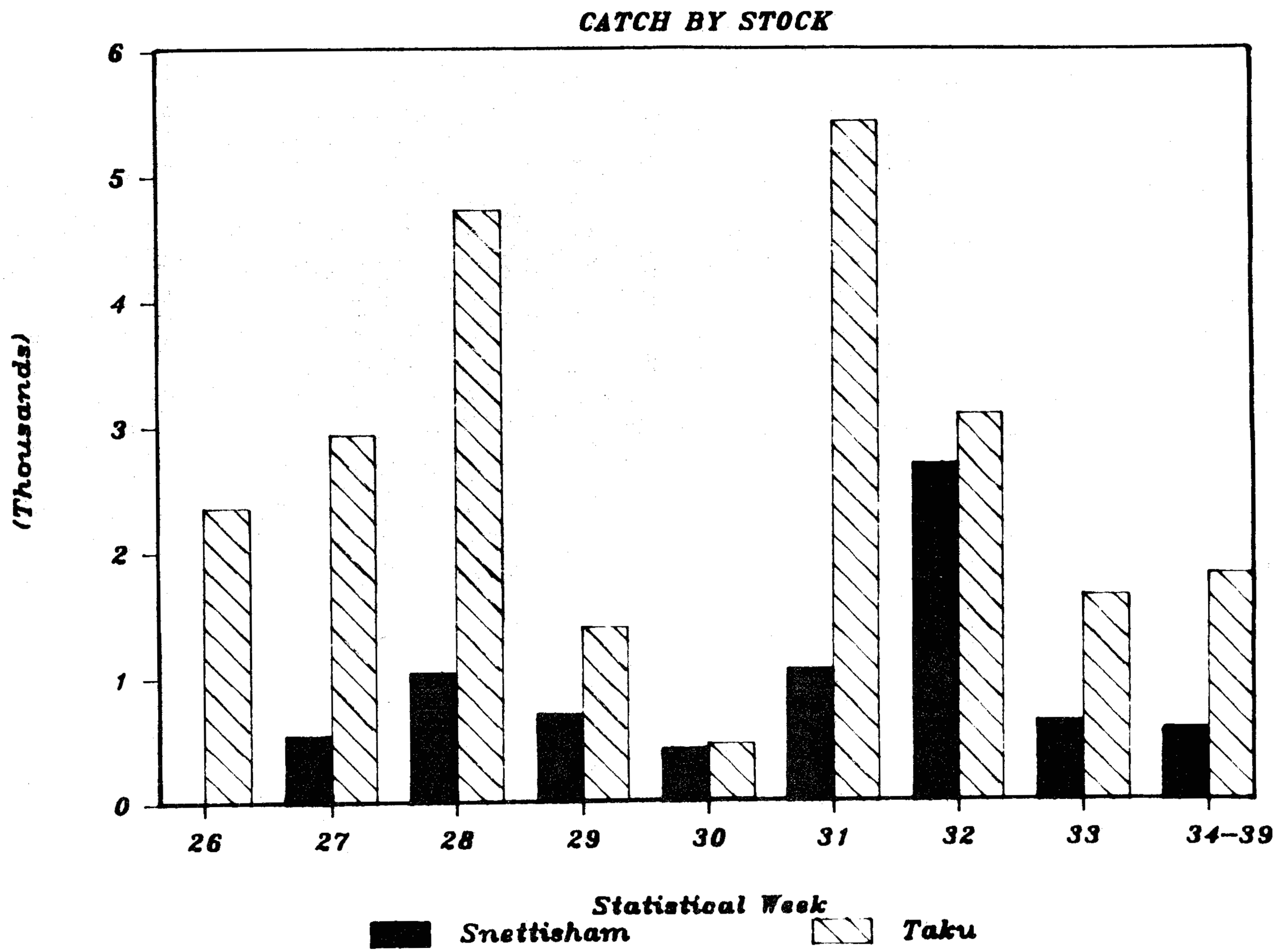

Figure 4. Harvest in numbers of fish by stock in the District 111 gillnet fishery, 1983.

Table 12. Run reconstruction statistics for the 1983 Port Snettisham sockeye salmon return.

	Age Class					
	1.2	1.3	2.2	2.3	Other	Total
Harvest	625	5,767	244	505	594	7,735
Escapement	14,646	11,289	819	1,867	1,255	29,906
Total Return	15,271	17,056	1,063	2,372	1,849	37,641

109, 110, 112, and 114. These fisheries target primarily on pink and chum salmon, but sockeye salmon are caught incidentally. A total of 30,201 sockeye salmon were taken in these fisheries in 1983. Age composition data for these fisheries suggest that Taku River fish could have contributed significant numbers to the catches (McGregor et al. 1984). Age 0.+ sockeye salmon, documented to occur in appreciable proportions in Southeastern Alaska escapements (excluding Yakutat) only in the Taku River drainage and the mainstem Chilkat River, were present in catches from all four districts and represented significant proportions of the catches in District 112 (9.2%) and District 114 (8.9%). Port Snettisham sockeye salmon likely utilize similar migration routes as Taku River fish and are probably intercepted to some degree in these fisheries as well. No effort has been expended to allocate the purse seine harvests from these districts to drainage of origin for several reasons: (1) the extreme mixed stock nature of the sockeye salmon catches complicates accurate stock allocation of the catches and, (2) catches in recent years in these fisheries have been small. The total return estimate generated in this report for Port Snettisham does not account for the possible interception of fish bound for District 111 in these fisheries.

A critical and previously missing aspect of the sockeye salmon management program for the District 111 gillnet fishery has been the ability to identify the origins of harvested fish. Scale pattern analysis has proven capable of solving the apportionment problem and, together with escapement enumeration programs, a base of total return data is now being developed. Continuation of this data base in future years will provide fishery managers with the means to forecast run size and manage the stocks for optimal escapement.

Sound management of the multi-stock Taku River sockeye salmon run requires greater knowledge of the age composition, harvest rates, and timing of the specific component stocks. Escapement estimation and stock-specific timing data is being generated by the ongoing tagging programs on the Taku River. The large amount of variability in Taku River scale growth patterns suggests that future work at apportioning both the Canyon Island fishwheel and Canadian in-river catches to individual stock of origin using scale pattern analysis might be successful. Concerted effort should be expended to collect scale data from all the major component stocks of the Taku River run.

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